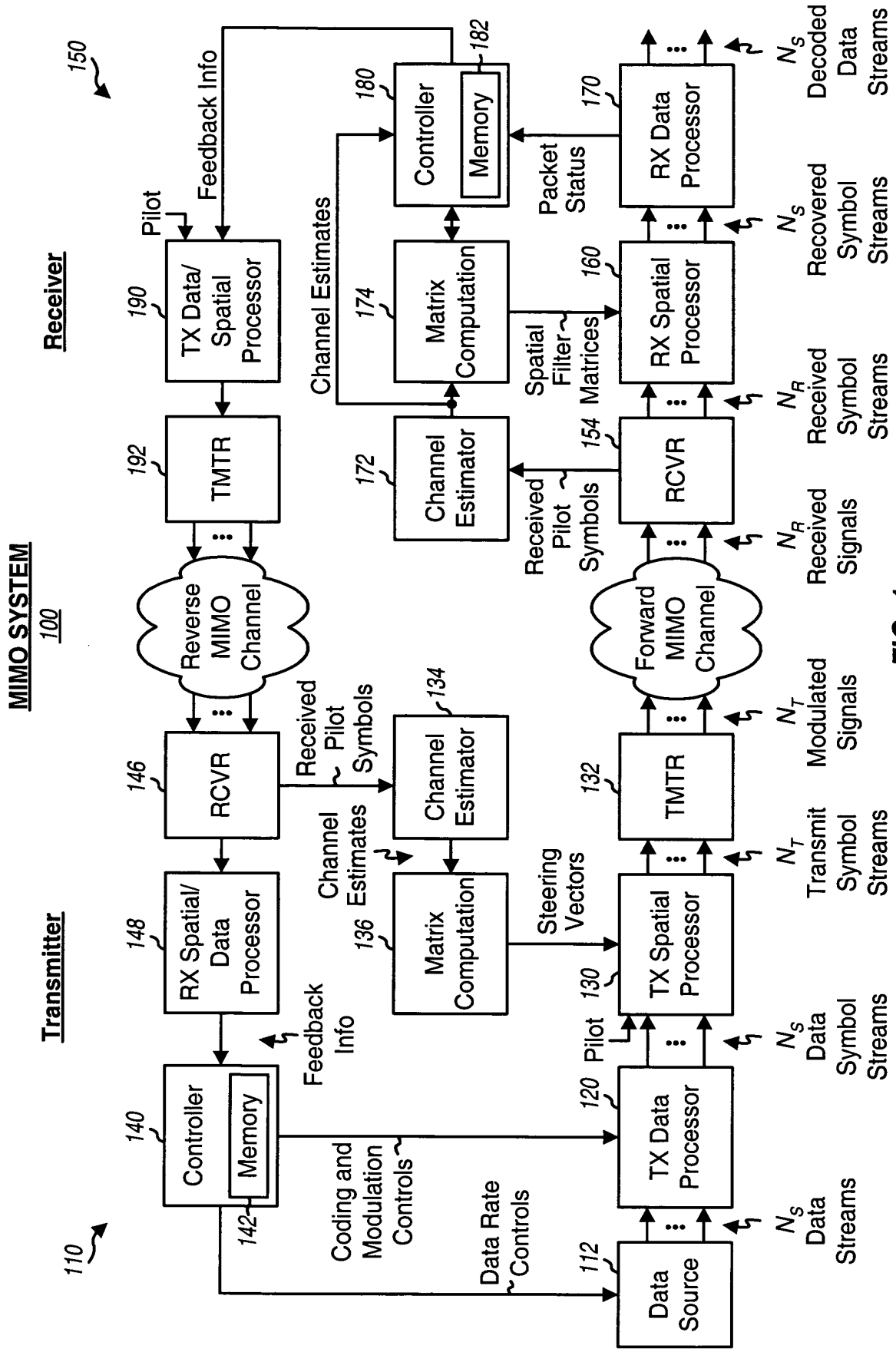
MIMO SYSTEM
100
Transmitter
Receiver
110
150
Data Source
112
TX Data Processor
120
TX Spatial Processor
130
TMTR
132
Channel Estimator
134
Matrix Computation
136
RX Spatial/ Data Processor
148
RCVR
146
Controller
140
Memory
142
Reverse MIMO Channel
Forward MIMO Channel
RCVR
154
Channel Estimator
172
Matrix Computation
174
TMTR
192
TX Data/ Spatial Processor
190
RX Spatial Processor
160
RX Data Processor
170
Controller
180
Memory
182
Pilot
Feedback Info
Channel Estimates
Spatial Filter Matrices
Packet Status
Received Pilot Symbols
Steering Vectors
Coding and Modulation Controls
Data Rate Controls
N_S Data Streams
N_S Data Symbol Streams
N_T Transmit Symbol Streams
N_T Modulated Signals
N_R Received Signals
N_R Received Symbol Streams
N_S Recovered Symbol Streams
N_S Decoded Data Streams

FIG. 1

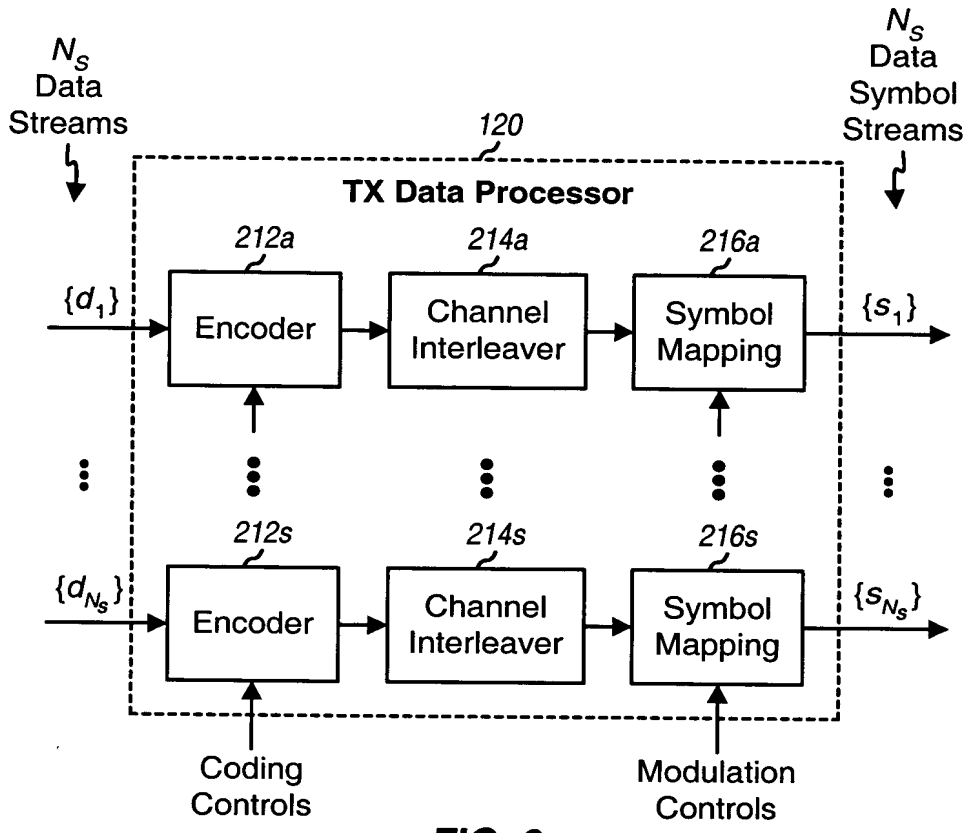
N_S Data Streams
120
N_S Data Symbol Streams
TX Data Processor
212a
214a
216a
$\{d_1\}$
Encoder
Channel Interleaver
Symbol Mapping
$\{s_1\}$
212s
214s
216s
$\{d_{N_S}\}$
Encoder
Channel Interleaver
Symbol Mapping
$\{s_{N_S}\}$
Coding Controls
Modulation Controls

FIG. 2

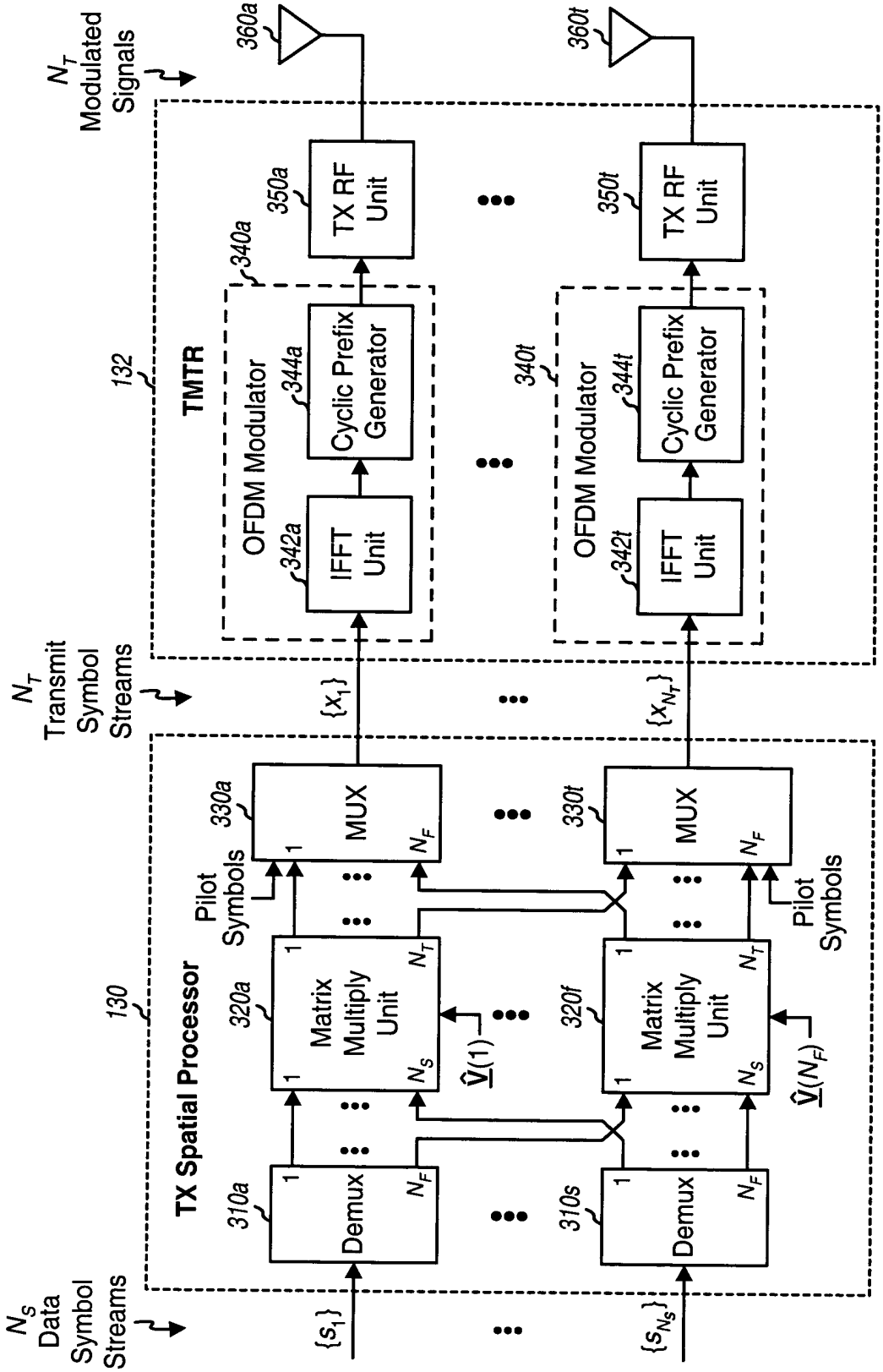
N_S Data Symbol Streams
N_T Transmit Symbol Streams
N_T Modulated Signals
130
TX Spatial Processor
132
TMTR
310a
Demux
310s
320a
320f
Matrix Multiply Unit
330a
330t
MUX
Pilot Symbols
340a
340t
OFDM Modulator
342a
342t
IFFT Unit
344a
344t
Cyclic Prefix Generator
350a
350t
TX RF Unit
360a
360t
$\{s_1\}$
$\{s_{N_S}\}$
$\{x_1\}$
$\{x_{N_T}\}$
$\hat{V}(1)$
$\hat{V}(N_F)$

FIG. 3

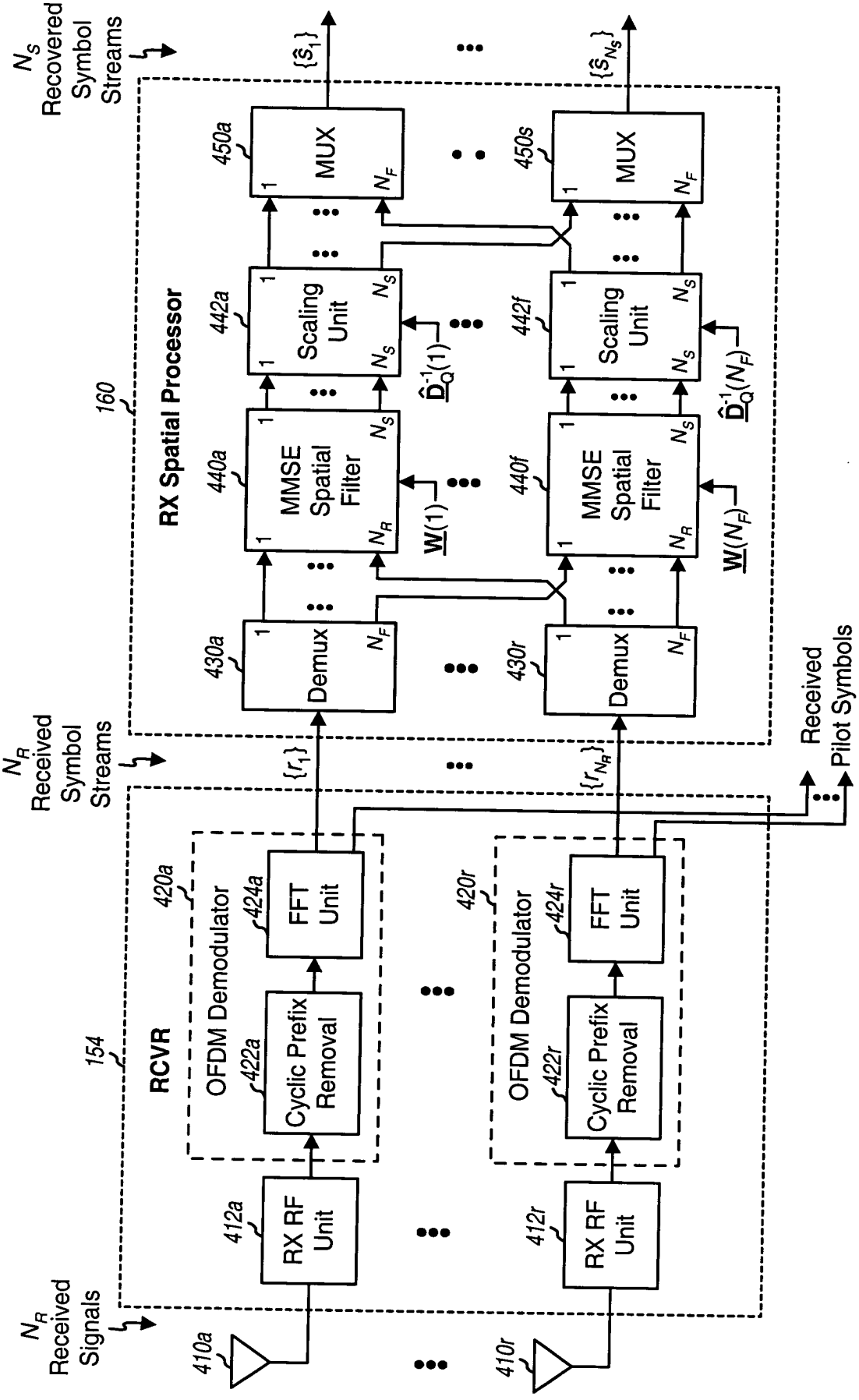
N_R Received Signals
410a
410r
RX RF Unit
412a
412r
RCVR
154
OFDM Demodulator
420a
420r
Cyclic Prefix Removal
422a
422r
FFT Unit
424a
424r
N_R Received Symbol Streams
$\{r_1\}$
$\{r_{N_R}\}$
Received Pilot Symbols
RX Spatial Processor
160
Demux
430a
430r
MMSE Spatial Filter
440a
440f
$\underline{W}(1)$
$\underline{W}(N_F)$
Scaling Unit
442a
442f
$\hat{\underline{D}}_Q^{-1}(1)$
$\hat{\underline{D}}_Q^{-1}(N_F)$
MUX
450a
450s
$\{\hat{s}_1\}$
$\{\hat{s}_{N_S}\}$
N_S Recovered Symbol Streams

FIG. 4

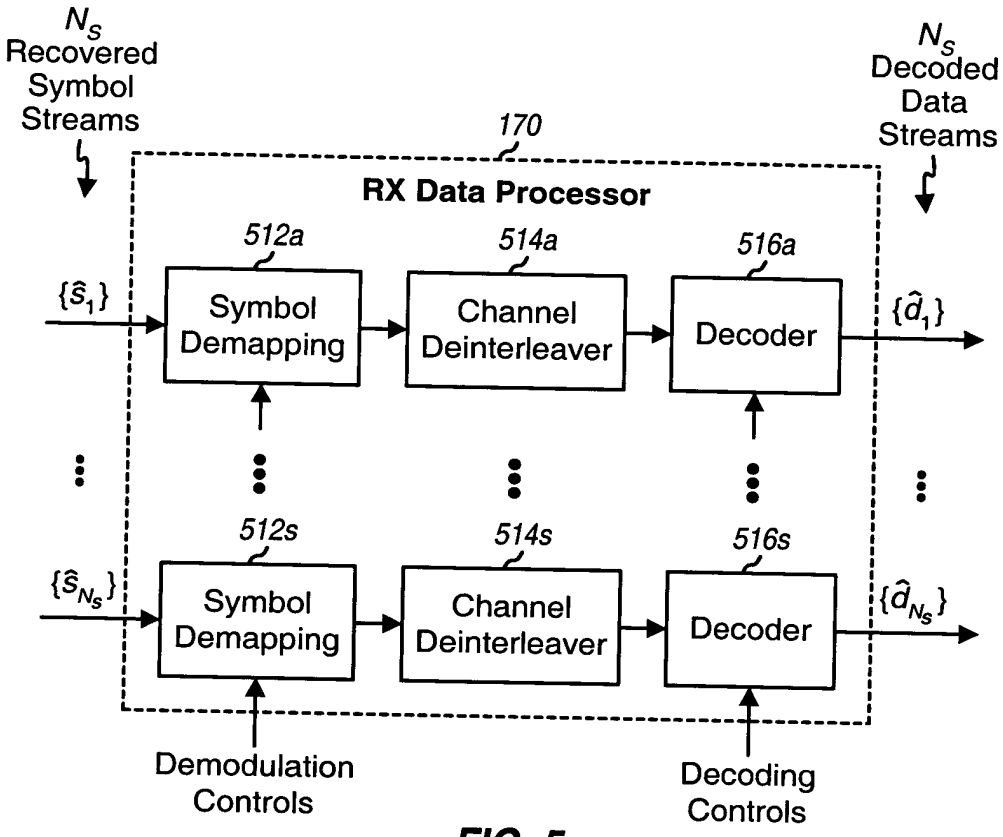
N_S Recovered Symbol Streams
170
RX Data Processor
N_S Decoded Data Streams
512a
514a
516a
$\{\hat{s}_1\}$
Symbol Demapping
Channel Deinterleaver
Decoder
$\{\hat{d}_1\}$
512s
514s
516s
$\{\hat{s}_{N_S}\}$
Symbol Demapping
Channel Deinterleaver
Decoder
$\{\hat{d}_{N_S}\}$
Demodulation Controls
Decoding Controls

FIG. 5

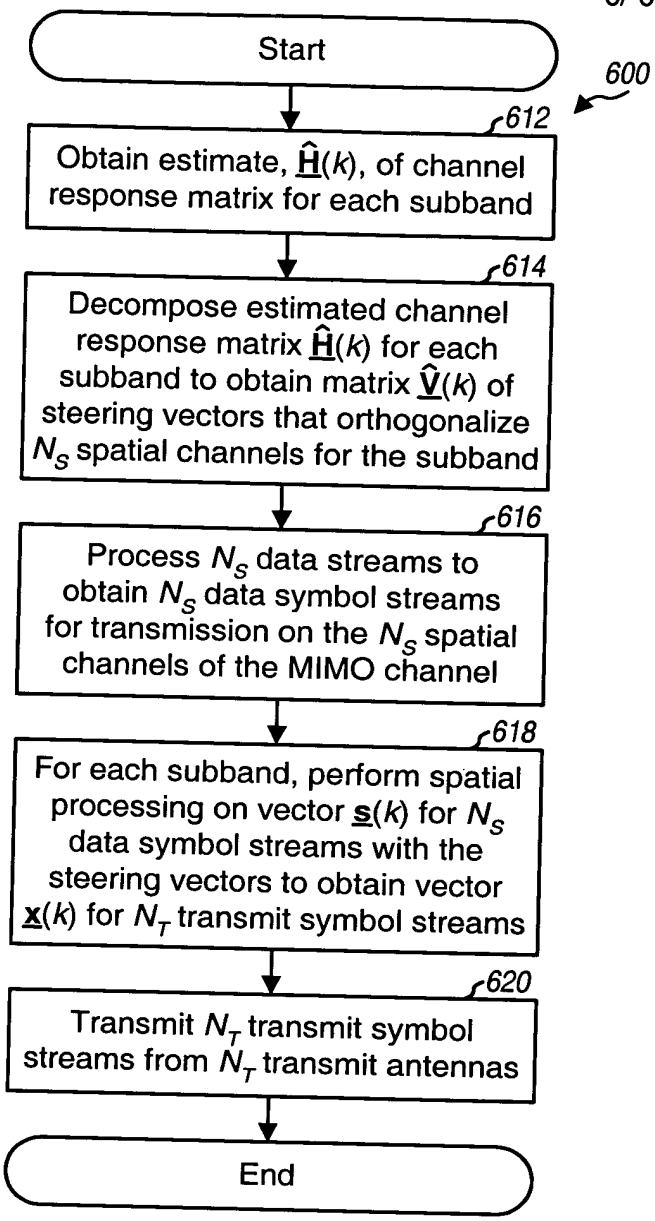
Start
600
612
Obtain estimate, $\hat{\underline{H}}(k)$, of channel response matrix for each subband
614
Decompose estimated channel response matrix $\hat{\underline{H}}(k)$ for each subband to obtain matrix $\hat{\underline{V}}(k)$ of steering vectors that orthogonalize N_S spatial channels for the subband
616
Process N_S data streams to obtain N_S data symbol streams for transmission on the N_S spatial channels of the MIMO channel
618
For each subband, perform spatial processing on vector $\underline{s}(k)$ for N_S data symbol streams with the steering vectors to obtain vector $\underline{x}(k)$ for N_T transmit symbol streams
620
Transmit N_T transmit symbol streams from N_T transmit antennas
End

FIG. 6

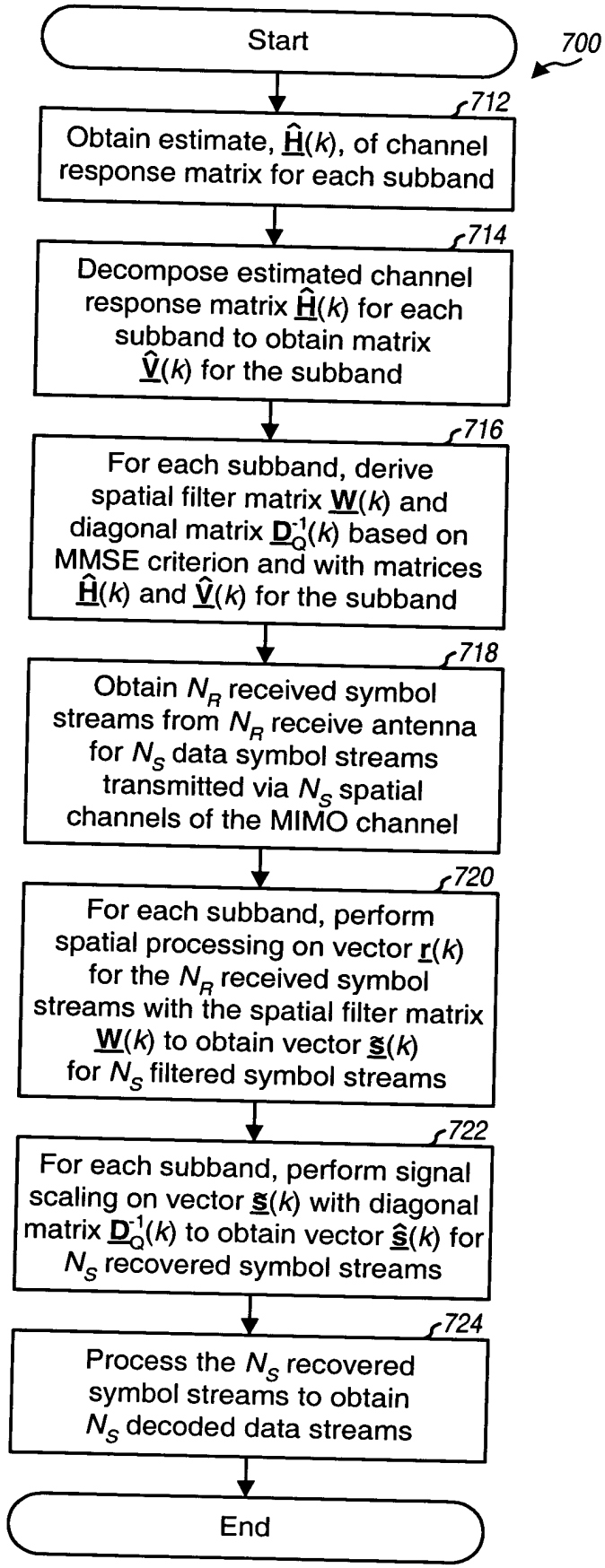
Start
700
712
Obtain estimate, $\hat{\underline{H}}(k)$, of channel response matrix for each subband
714
Decompose estimated channel response matrix $\hat{\underline{H}}(k)$ for each subband to obtain matrix $\hat{\underline{V}}(k)$ for the subband
716
For each subband, derive spatial filter matrix $\underline{W}(k)$ and diagonal matrix $\underline{D}_Q^{-1}(k)$ based on MMSE criterion and with matrices $\hat{\underline{H}}(k)$ and $\hat{\underline{V}}(k)$ for the subband
718
Obtain N_R received symbol streams from N_R receive antenna for N_S data symbol streams transmitted via N_S spatial channels of the MIMO channel
720
For each subband, perform spatial processing on vector $\underline{r}(k)$ for the N_R received symbol streams with the spatial filter matrix $\underline{W}(k)$ to obtain vector $\tilde{\underline{s}}(k)$ for N_S filtered symbol streams
722
For each subband, perform signal scaling on vector $\tilde{\underline{s}}(k)$ with diagonal matrix $\underline{D}_Q^{-1}(k)$ to obtain vector $\hat{\underline{s}}(k)$ for N_S recovered symbol streams
724
Process the N_S recovered symbol streams to obtain N_S decoded data streams
End

FIG. 7